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मानक

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IS 12514 (1988): Method for torsional stress fatigue testing [MTD 3: Mechanical Testing of Metals]



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“Knowledge is such a treasure which cannot be stolen”



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*Indian Standard***METHOD FOR TORSIONAL STRESS FATIGUE TESTING****1. Scope**

**1.1** This standard specifies the conditions for carrying out torsional stress fatigue tests on test pieces having a nominal diameter between 5 and 12.5 mm without deliberately introduced stress concentrations. The tests are carried out at room temperature in air, by applying to the test piece a pure couple about its longitudinal axis.

**1.2** The form, preparation and testing of test pieces of circular cross-section are specified but component testing and other specialized form of tests are not included. Similarly, high strain torsional fatigue tests, which lead to failure in a few thousand cycles, are also excluded.

**2. Principle**

**2.1** Nominally identical test pieces are mounted in a torsional fatigue testing machine and subjected to the loading conditions required to induce cycles of torsional stress having the form of any one of the stress cycles illustrated in diagrams 4 to 7 of Fig. 1.

**Note** — Diagrams 1 to 3 of Fig. 1 are not relevant since in an axially symmetrical test piece, change of direction of mean torque does not induce a different type of stress system, and mean stress in torsion can always be regarded as positive in sign.

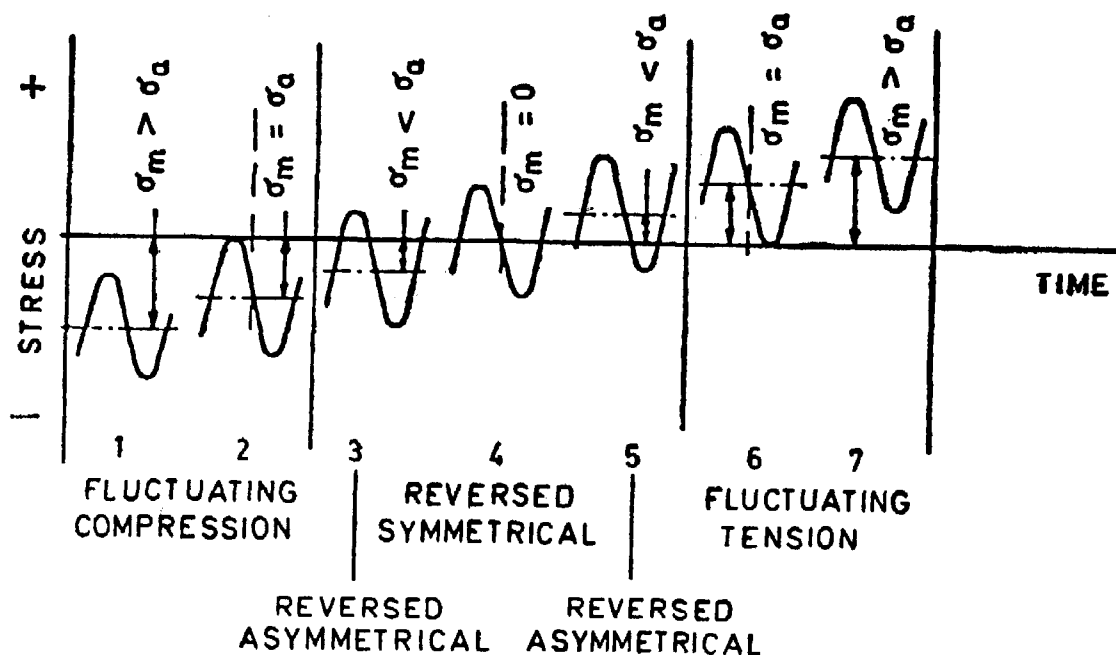


FIG. 1 TYPES OF CYCLIC STRESS

**2.2** The purpose of the test is to determine fatigue properties, such as, the  $S/N$  curve. The test being continued until the test piece fails by complete fracture or until a pre-determined degree of cracking has been achieved or a predetermined number of stress cycles has been exceeded.

**Note 1** — The form of cracking experienced as a result of torsional fatigue testing may be of different configurations. Cracks may be parallel to the longitudinal axis of the test piece, or perpendicular to the longitudinal axis, or at any angle between these two.

**Note 2** — Results of fatigue tests may be affected by atmospheric conditions, and if controlled conditions are required, these shall be agreed to between the purchaser and the supplier.

**3. Symbols** — The following symbols ( *see* Fig. 2 and 3 ) have been used in this standard:

**Symbol**

**Definition**

$D$

Diameter or width across flats of the gripped ends of the test piece. The value of  $D$  may be different for each end of the test piece.

$d$

Diameter of the test piece where the stress is a maximum.

$L_c$

Parallel length of the test piece.

$r$

Transition blending radius at the ends of the test section which starts the transition from the test diameter  $d$  to the end diameter  $D$  [ *see* Fig. 2(a) ] or the single radius between the gripped ends [ *see* Fig 2(b) ].

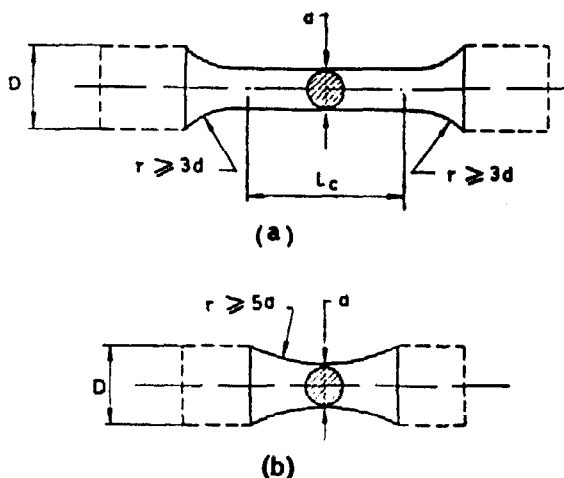


FIG. 2 FORMS OF TEST PIECE

**4. Test Pieces**

**4.1 Form**

**4.1.1** The test section shall be either:

- cylindrical with tangentially blending radii at each end of a parallel length:  $L_c$  [ *see* Fig. 2(a) ], or
- of continually varying circular cross-section, its surface formed by a single radius  $r$ , there being no central parallel portion.

**4.1.2** The ends of the test piece shall be of a form to suit the holders of the machine being used and the material being tested. Screwed and plain cylindrical ends are not recommended. Typical test piece ends are shown in Fig. 3.

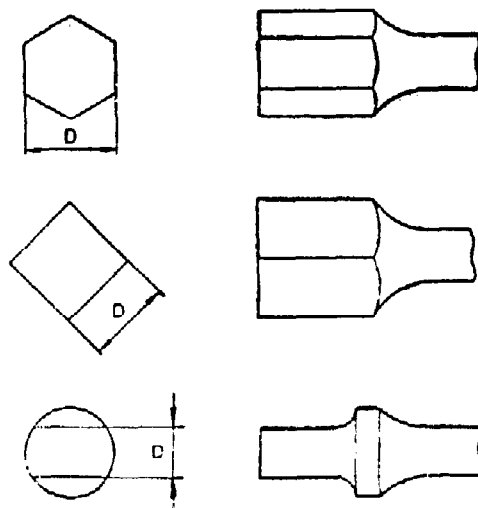


FIG. 3 TYPICAL TEST PIECE ENDS

## 4.2 Dimensions

**4.2.1** The nominal value of diameter  $d$  shall be between 5 and 12.5 mm; the tolerance on diameter  $d$  shall be  $\pm 0.05$  mm.

**4.2.2** For the purpose of calculating the torque to be applied to obtain the required stress, the actual diameter of each test piece shall be measured to an accuracy of 0.01 mm. Care should be taken during the measurement of the test piece prior to testing so that the surface is not damaged.

**4.2.3** In the case of a cylindrical test piece having a parallel test section, this test section shall have a length not greater than  $5d$  and it shall be parallel within 0.02 mm. The transition blending radius at the end of the parallel test section shall have a radius not less than  $3d$ .

**4.2.4** In the case of a test piece having a test section formed by a continued radius, this radius shall be not less than  $5d$ .

## 5. Preparation of Test Piece

### 5.1 General

**5.1.1** It is essential that any cutting or machining operation required, either to rough out the test piece from the blank, or to finish it to size, shall not alter the metallurgical structure or the mechanical properties of test piece or induce substantial residual surface stress.

**5.1.2** Care should be taken in the preparation of the ends of the test piece to ensure that the requirements of 6 can be met.

**5.2 Turning** — It is recommended that the following procedure be adopted.

**5.2.1** In rough turning the test piece from a diameter  $X + 5$  mm ( $X$  will generally be the diameter  $d$ , plus a suitable allowance for surface finishing) to  $X + 0.5$  mm, a succession of cuts of decreasing depth should be made, the recommended depths of cuts being:

1.25, 0.75 and 0.25 mm.

**5.2.2** From a diameter of  $X + 0.5$  mm to  $X$ , a further succession of cuts of decreasing depths should be made, the recommended depths of cuts being:

0.125, 0.075 and 0.05 mm.

using for these finishing cuts a feed not exceeding 0.06 mm per revolution.

### 5.3 Grinding

**5.3.1** For test pieces in material which cannot be readily turned, it is recommended that the finishing operations be carried out by grinding. If the strength properties of the material are developed by heat treatment, this heat treatment may be carried out after rough turning to a diameter of  $X + 0.5$  mm.

**5.3.2** The test piece should then be ground to size. A succession of cuts of decreasing depth should be made, the recommended values being:

- 0.030 mm depth of cut to 0.1 mm oversize,
- 0.005 mm depth of cut to 0.025 mm oversize, and
- 0.0025 mm depth of cut to size.

### 5.4 Surface Finishing

**5.4.1** After the testing section has been machined or ground to nominal dimensions, it shall be polished either by hand or by machine, using successively finer grades of abrasive papers or cloths. The polishing should generally be in a circumferential direction although intermediate stages may be done in any direction to ensure that scratches made by the coarser grades of abrasive papers or cloths are removed. The direction of final polishing should mainly be circumferential.

**5.4.2** The polishing sequences employed should be such that the finished test section has a surface roughness  $R_a$  of less than  $0.025 \mu\text{m}$ . It will usually be found satisfactory to arrange the sequence of polishing so that the paper used is 600 grade.

## **5.5 Storage Prior to Testing**

**5.5.1** If deterioration of the surface has taken place during storage, the test piece shall be repolished to remove any surface defects, for example, corrosion pits.

**Note**—The procedures given in 5.2, 5.3 and 5.4 represent standard practice for a wide range of materials. It should not be inferred that they are wholly applicable to all materials and to all heat-treated conditions of these materials. For example, the allowance of 0.5 mm on diameter  $X$ , for heat treatment prior to final grinding to size may not be adequate. The purpose of this allowance is to permit the removal of surface phenomena associated with the heat treatment procedure such as decarburization, distortion, etc. and the allowance should be such as to ensure the complete removal of any features associated with such effects.

**5.5.2** Some fatigue investigations may be undertaken to study the behaviour of material with particular surface finishes, for example, rough machined or fine machined, or in the 'as received' condition, in which case special conditions would apply.

## **6. Mounting of Test Piece**

**6.1** The test piece shall be mounted in the testing machine in such a manner that stresses at the test section other than those imposed by the applied load are avoided and such that no bending stresses are introduced at the test section.

**6.2** Care should be taken such that the axis of the test piece lies along the axis of torsion of the testing machine.

## **7. Speed of Testing**

**7.1** The frequency of the stress cycle will depend upon the type of testing machine employed and in many cases, upon the stiffness of the test piece.

**7.2** The testing speed chosen should be that which is most suitable for the particular combination of material, test piece and testing machine, having regard to the heating which can occur due to rapid dissipation of strain energy in the test piece.

## **8. Application of Torque**

**8.1** The general procedure for attaining full torque running conditions should be the same for each test piece.

**8.2** If frequencies are determined from dynamic characteristics of the test piece and the testing machine combination, it may be necessary to measure the stiffness of the test piece before the commencement of testing.

**8.3** In general, the application of the mean torque is followed by adjustment of the fluctuating torque.

**8.4** During the early stages of the test, check the torque frequently to ensure that the required conditions are maintained. Then adjust and set the torque-maintaining devices and the test piece fracture cut-off switches.

**8.5** At frequent intervals throughout the test period, monitor the torque to ascertain that the torque conditions have not changed.

**8.6** The mean torque and the torque range, as determined by a suitable method of calibration, shall be accurate to within 3 percent of their nominal values or to within 0.5 percent of the maximum torque of the machine range employed, whichever is greater.

**Note** — Some users of torsional stress fatigue testing machines rely entirely on static calibration. However, the dynamic response of the machine may be appreciably different from the static behaviour and for verifying the accuracy of the fluctuating torque, a dynamic calibration is to be preferred. It is not considered feasible at the present time to attempt to standardize a method of calibration.

**9. Endurance** — The  $S/N$  curve for certain materials shows a distinct change of slope after a given number of cycles, the curve becoming parallel to the horizontal axis. For other materials, the shape of the  $S/N$  curve may be continuous, becoming asymptotic with the horizontal axis. If  $S/N$  curves of the first type are experienced, it is recommended that the endurance used as a criterion of failure be  $10^7$  cycles. For  $S/N$  curves of the second type, the endurance should be  $10^8$  cycles.

**10. Test Report** — The test report shall include the following information:

- a) The type and nominal dimensions of the test piece and the surface finish of the test section;

- b) The material tested, its metallurgical condition including details of any heat treatment and the references of any Indian Standard to which the material was produced;
- c) The frequency and the type of stress cycle, the minimum and maximum stress and the type of testing machine used;
- d) Where practicable, the temperature of the test piece, if this is significantly higher than that of the test environment;
- e) The range of relative humidity if this is outside the range of 50 to 70 percent ( the range of relative humidity should be measured everyday throughout the duration of the test );
- f) Any deviation from the specified conditions during the test; and
- g) The criterion of failure, if other than the complete failure of the test piece, for example,  $10^7$  or  $10^8$  cycles.

**Note 1** — In the majority of fatigue determinations, the criterion of failure is either the occurrence of visible fatigue cracks or a complete fracture. It should be noted, however, that for particular applications, other criteria, for example, plastic deformation of the test piece or rate of crack propagation, may be adopted to determine the end of the test.

If required, and particularly if low frequencies and high stresses are employed, the criterion of failure shall be the subject of agreement.

**Note 2** — Test results may be presented graphically.

## EXPLANATORY NOTE

In the preparation of this standard, assistance has been derived from ISO 1352-1972 'Steel — Torsional stress fatigue testing', issued by the International Organization for Standardization ( ISO ).